Airport Capacity Evaluation and Flights Operation

China Academy of Civil Aviation Science and Technology, CAST

2021.5

CONTENTS

22 Primary Coordination Airport，L3

15 Secondary Coordination Airport，L2

Slot Management of Civil Aviation (2018)

民航航班时刻管理办法

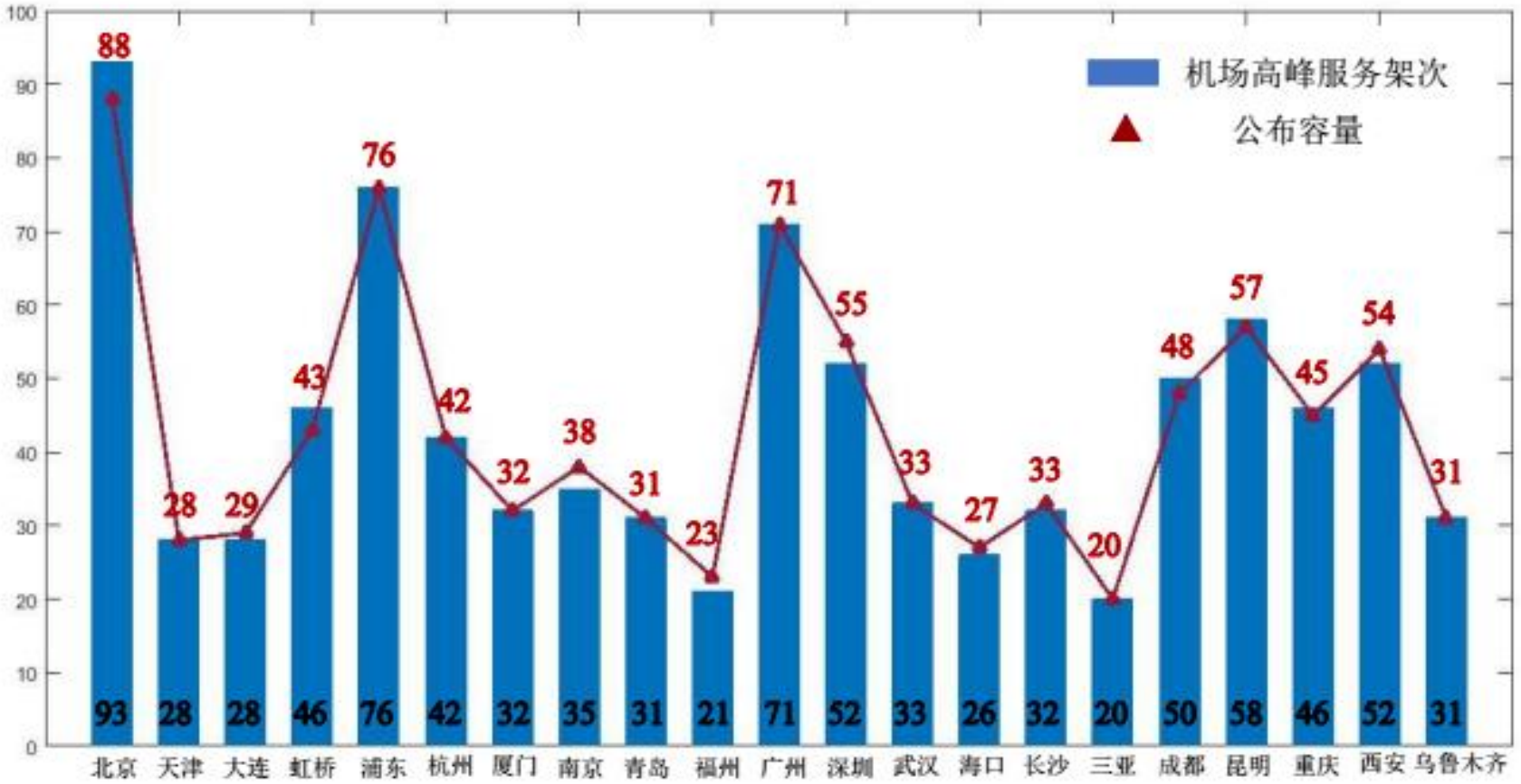
第一章 总 则

第一条 为了规范民航航班时刻管理工作，促进航班时刻资源配置的公平、高效、竞争和廉政，促进民航航班运行的正常与有序，深入推进民航业供给侧结构性改革，助推民航强国战略目标实现，根据《民用航空法》的有关规定，制定本办法。

第二条 本办法所称航班时刻，是指航空器在指定日期和时间，为抵离某个机场而使用相关基础设施与服务的权利。航班时刻的时间基于挡轮挡时间和撤轮挡时间。

第三条 本办法适用于航班时刻主协调机场、辅协调机场的时刻管理工作，人道主义、专机、应急、外交等紧急重要飞行除外。重大航空运输、公务、校验、调机以及通用等飞行的时刻管理办法另行规定。

Support Slot Management



Level 3

↗ The demand for airport infrastructure significantly exceeds the capacity of the airport

↗ All airlines must operate with an agreed and allocated slot

↗ A coordinator is appointed to allocate slots and manage the available airport capacity

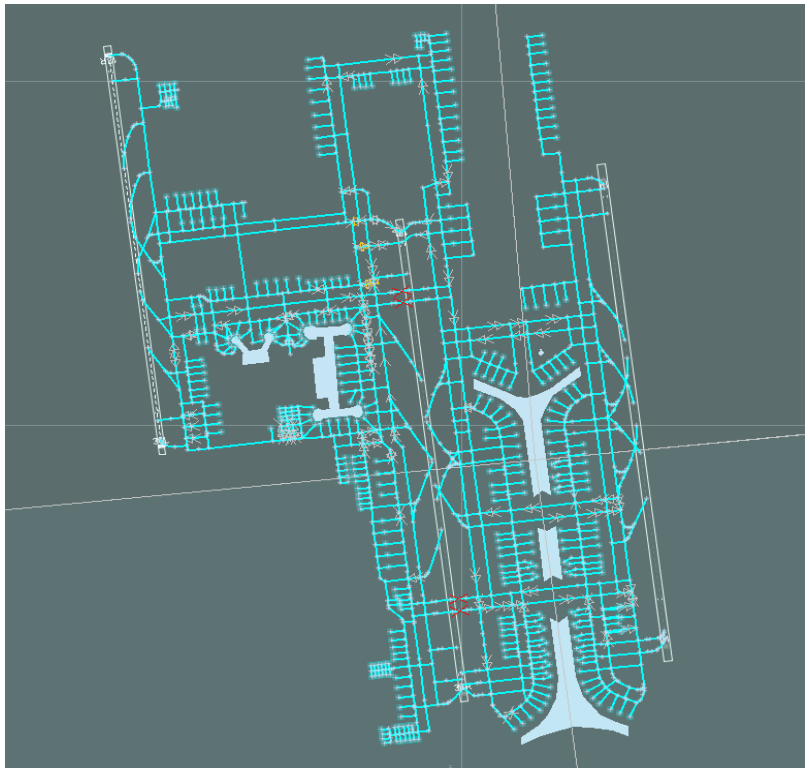
Airport Peak Hour Movements

Airport Declared Capacity

1.What is the Airport Capacity

Definition

- Capacity（throughput capacity）is a measure of the maximum number of aircraft operations which can be accommodated on the airport or airport component in an hour.
- Airport Capacity is the hourly throughput （arrivals and departures）an Airport system is able to sustain during periods of high demand.
  - Expressed as hourly arrival-departure rates.



1.What is the Airport Capacity

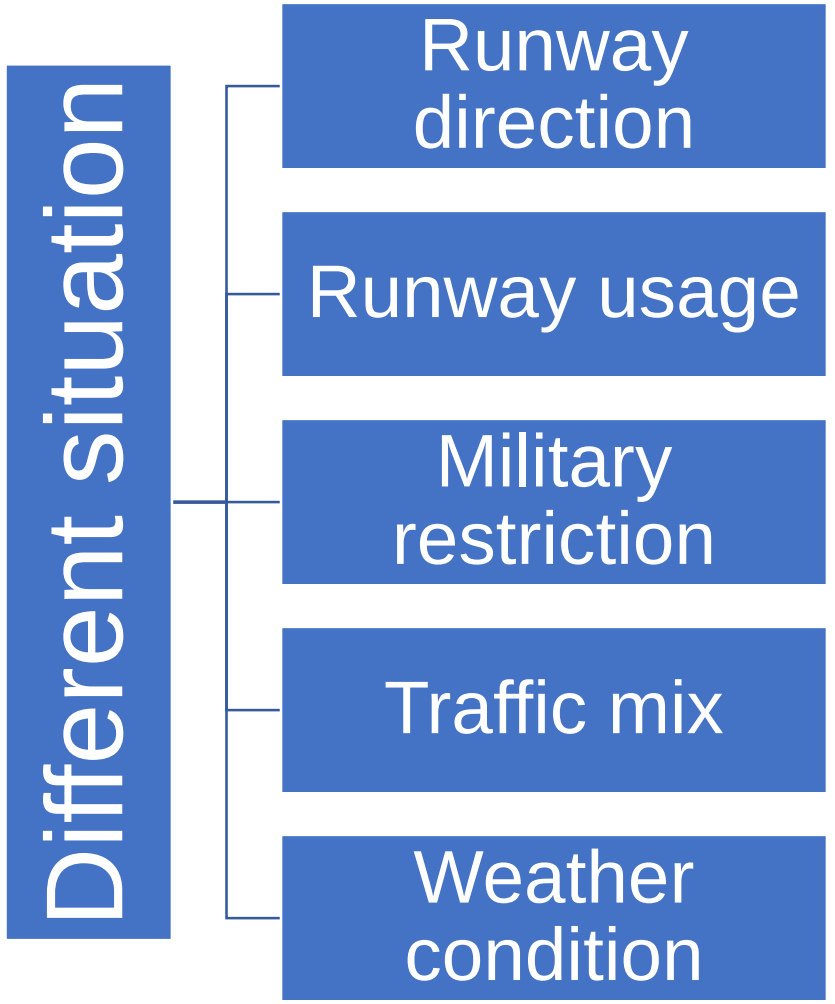
Airport Declared Capacity

- The declared capacity is a parameter decided months before operations considering:
  - the type of traffic demand;
  - the typical operational capacity;
  - the desired level of service requested by aircraft operators.

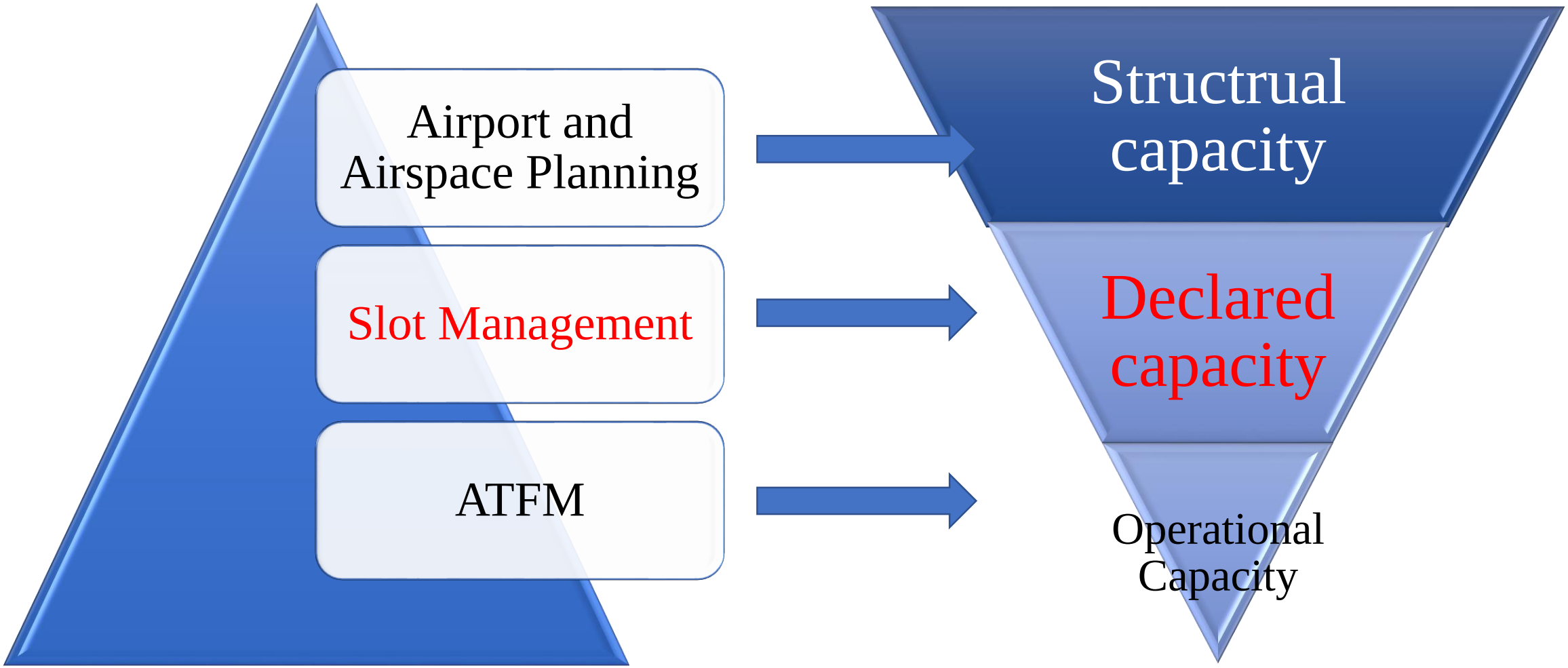
1.What is the Airport Capacity

Airport Operational Capacity

- **The operational capacity** is set according to the specific situation of the day or hours of operations(weather /status of systems and infrastructures)



1.What is the Airport Capacity



Evaluate the Airport Declared Capacity for SLOT MANAGEMENT

1.What is the Airport Capacity

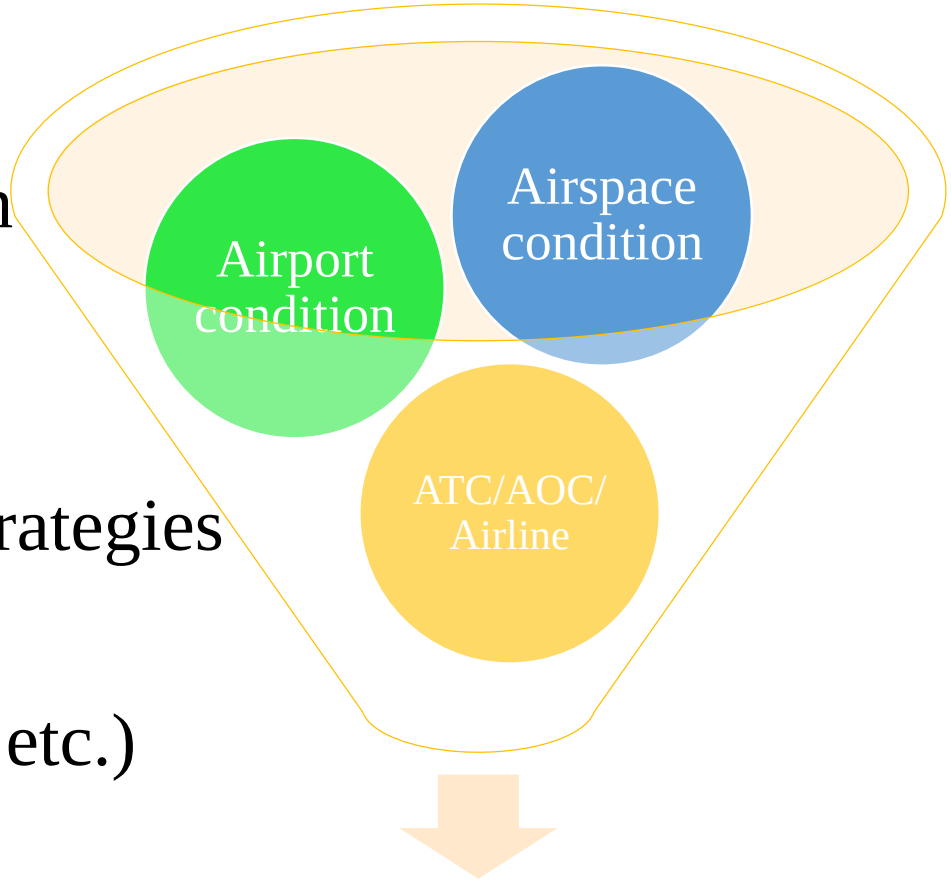
What is the purpose of the capacity analysis?

	To analyze a capacity change					
Airfield changes:	New runway	■	■	■	■	■
	New taxiway/apron/gates					■
	Runway crossings and incursions					■
	Navigational aid critical areas					■
	Effects of airport traffic control towers			■	■	■
Airspace changes:	Changes in flight procedures			■	■	■
	Noise abatement procedures				■	■
	In-trail terminal airspace restrictions					■
	Multiple approach procedures			■	■	■
	Changes in ATC rules and separations					■
	ATC workload and human factors			■	■	■
	NextGen benefits of reduced aircraft separations and new airspace procedures			■	■	■
Aircraft changes:	Aircraft fleet mix and stage length changes			■	■	■
	To estimate aircraft delay					■
	To estimate ASV/hourly capacity	■	■			
	To compare with hourly demand			■	■	■
	To benchmark with other airports	■	■	■	■	■
	To evaluate flight schedules			■	■	■
	To compare alternative airfield facility or procedural improvements			■	■	■
	To provide data for follow-on environmental studies			■	■	■
	To provide proof-of-concept testing	■	■	■	■	■
	To provide information to educate elected officials, the general public, or other stakeholders	■	■	■	■	■

2.What major matters should be forcus on

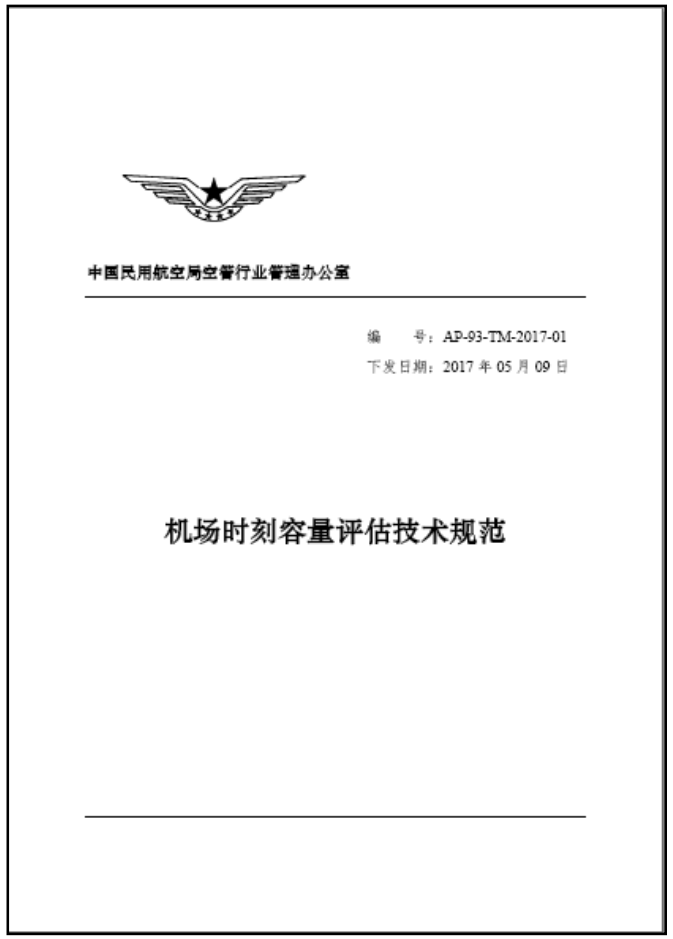
Airport Capacity Affect Factors:

- Airport Layout/Runway Configuration
- Movement Mix
- Aircraft Characteristics
- Airspace Structure and Operational Strategies
- STARs / SIDs
- Technology Application(Point Merge, etc.)
- ATC Separation Standards /AOC…



Airport Capacity

2.What major matters should be forcus on



中国民用航空局空管行业管理办公室

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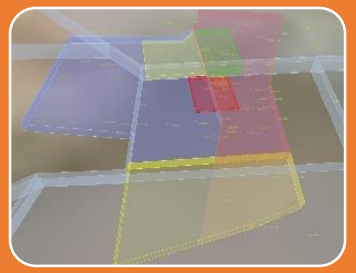
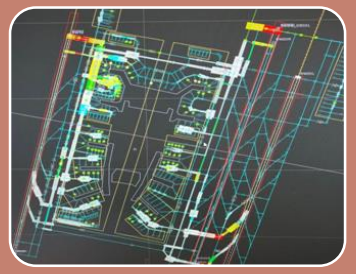
机场时刻容量评估技术规范

Technical Specifications of Airport Capacity Evaluation



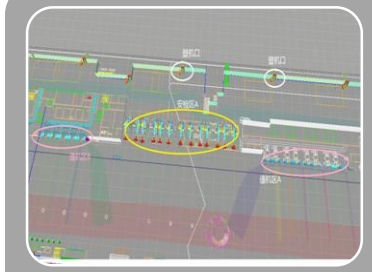
Airspace range

- Terminal area, en-routes;Flight procedures;
- Separation standards;Interval standards, Transfer agreements, and other airspace regulatory requirements.



Airport airside range

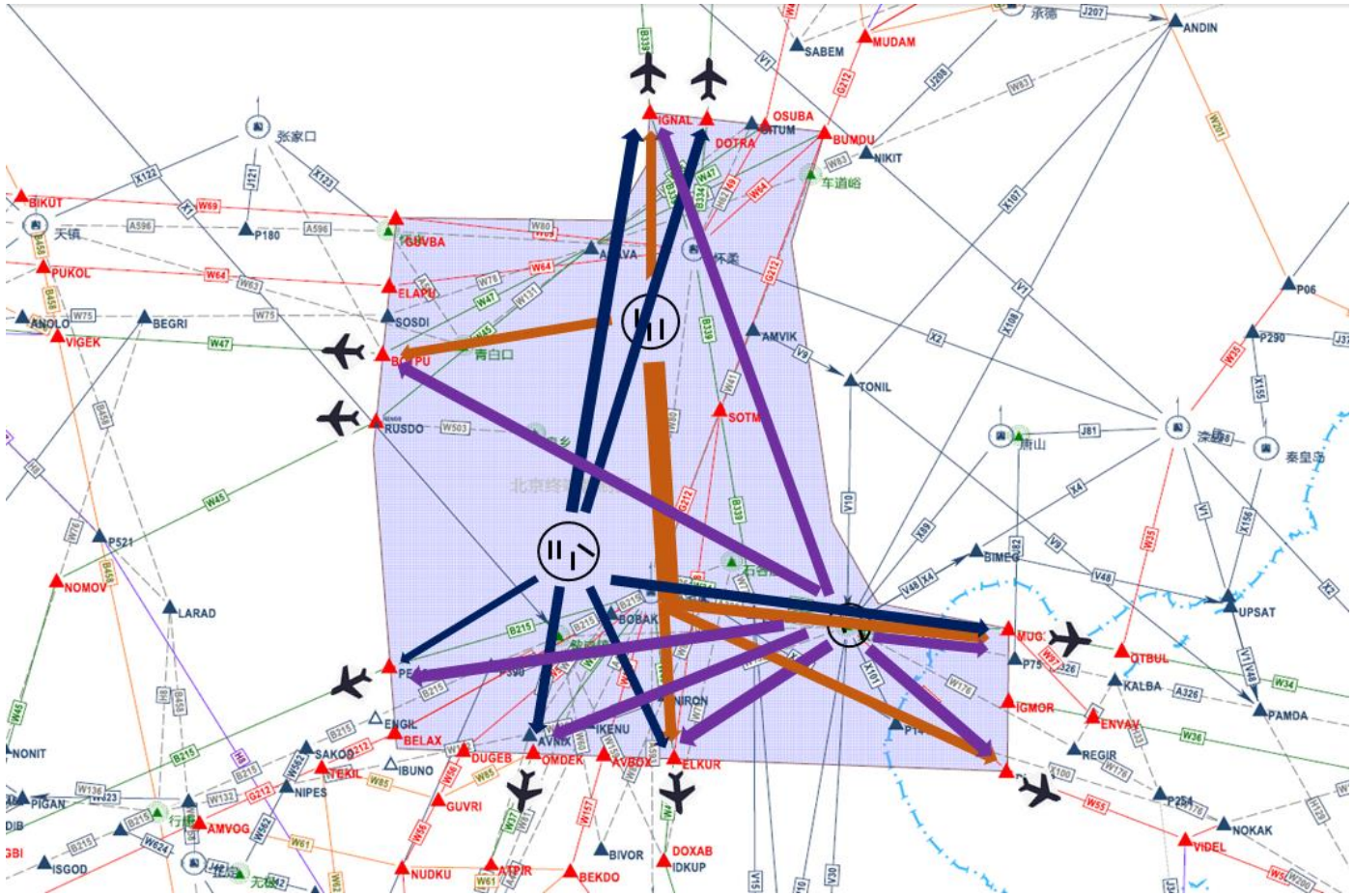
- Runways, taxiways, aprons, parking position,etc.:
- Operating rules and limits for each unit.



Airport land side range

- Key points such as security check and check-in in the terminal building;
- Related technical indicators.

2.What major matters should be forcus on



Airspace

Structure:

Routes,Waypoints,Sectors,

STARs， SIDs ,Holding

Rules:

Transfer rules, Separation standards,

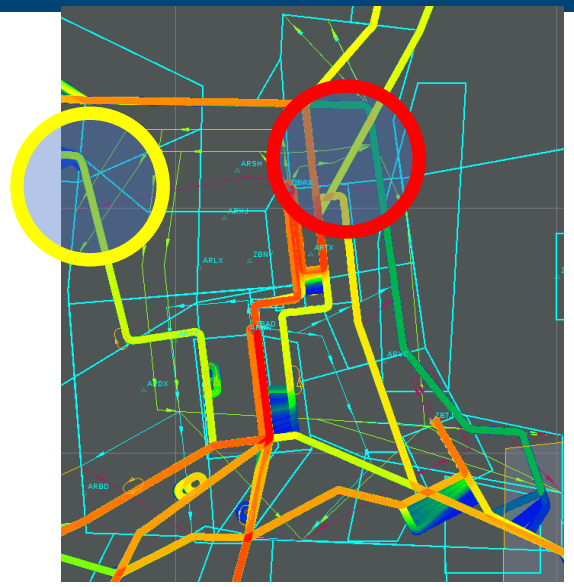
ATCSectorEntryRule，

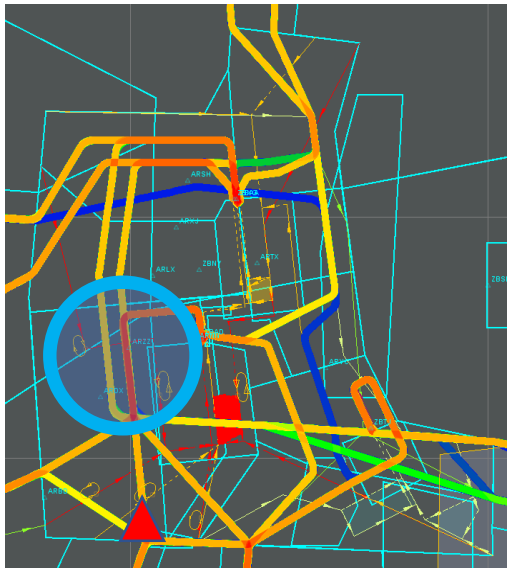
WaypointRule，

EnterHoldingAndUseRoutingRule

…

2.What major matters should be forcus on





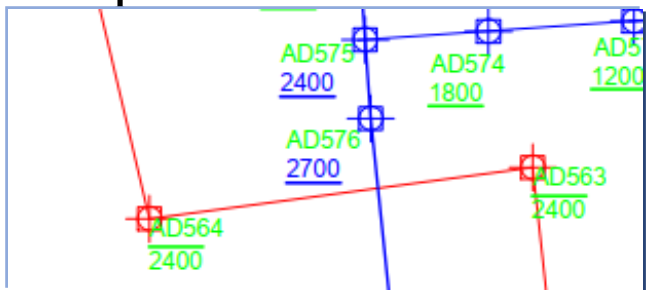
Flight Procedures: Altitude, Speed, Climb/Descend Rate…

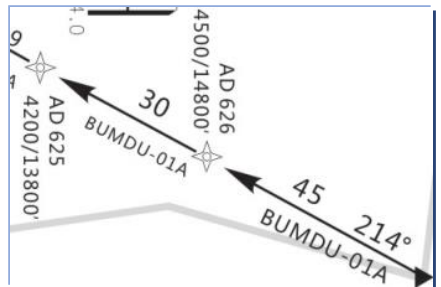
1.ELAPU (Yellow Ring) 35L/35R Arrival(new) request descend to 2400m ASAP but still over the mountains.

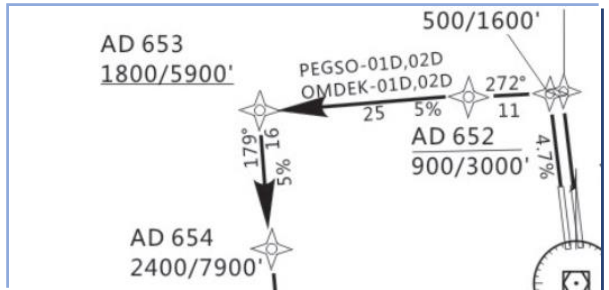
2.BUMDU(Red Ring) 35L/35R Arrival maintain 4200m-4800m nearly 18 minutes. Descend Too Early.

3.OMDEK (Blue Ring) 35L/35R Departure

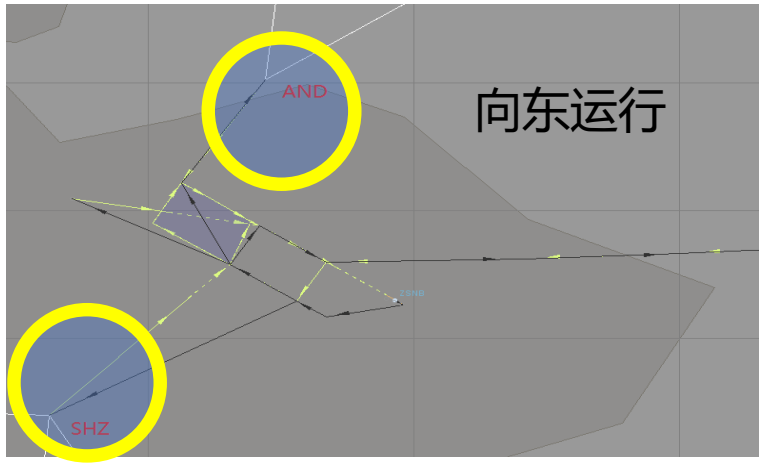
request maintain 2400m before AD654. Climb Too Late

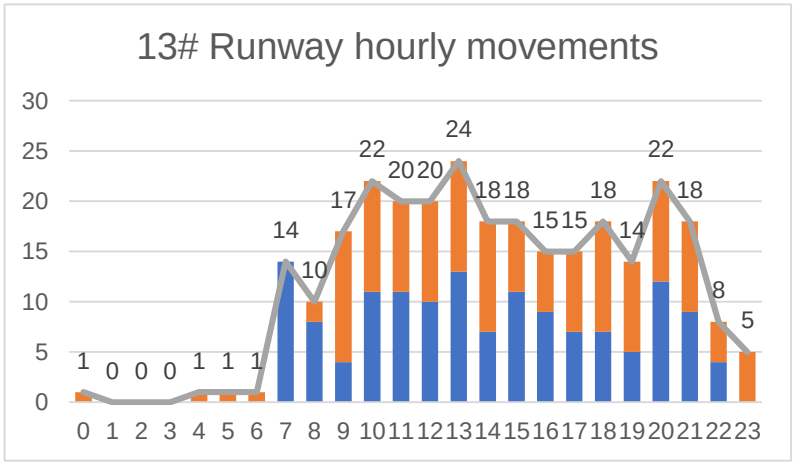


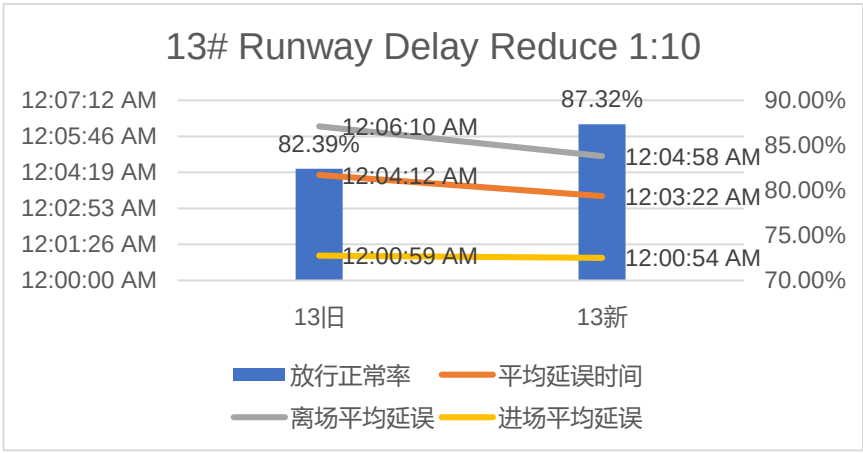


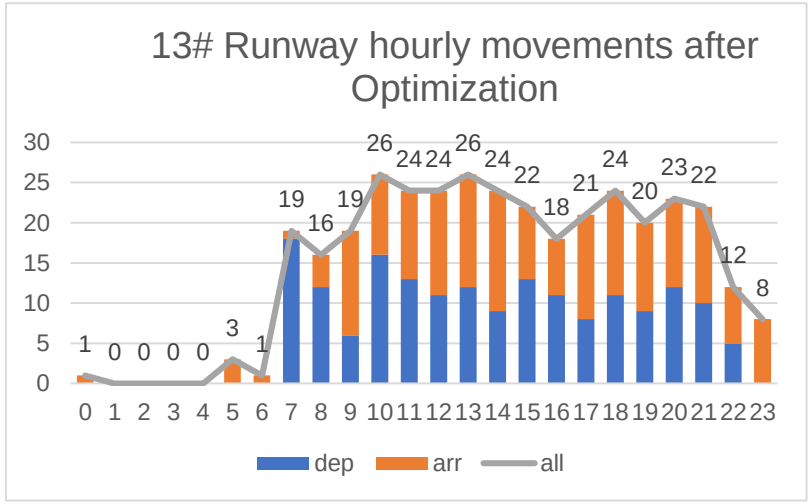


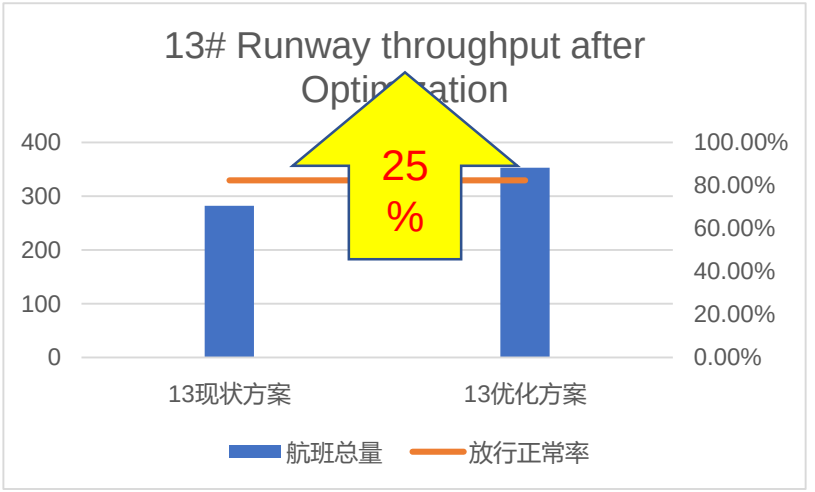
2.What major matters should be forcus on











2.What major matters should be forcus on

Airport

Layout:

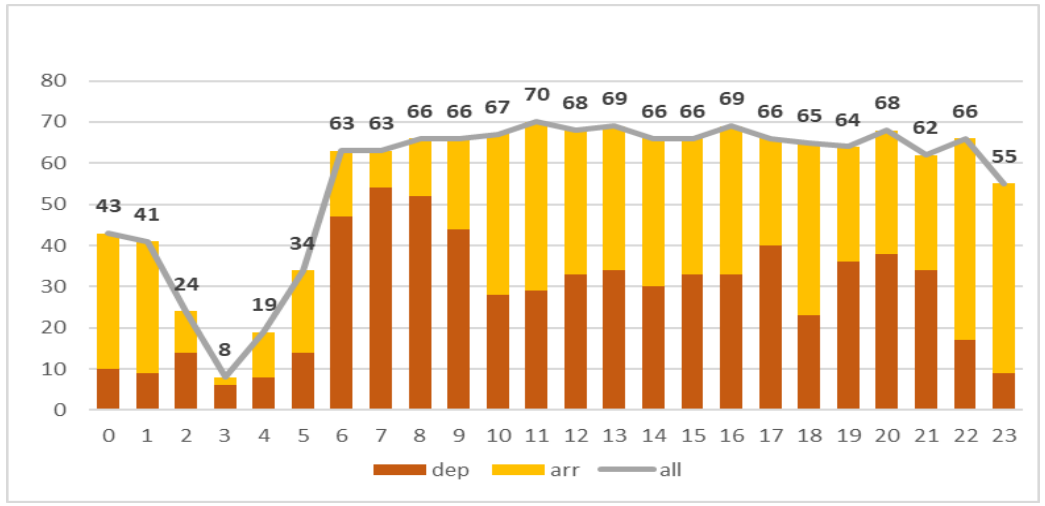
Runway,Runway Entry,
RunwayExit,Runway Crossing Taxiway,
Parkingposition,StopBar

Rules：

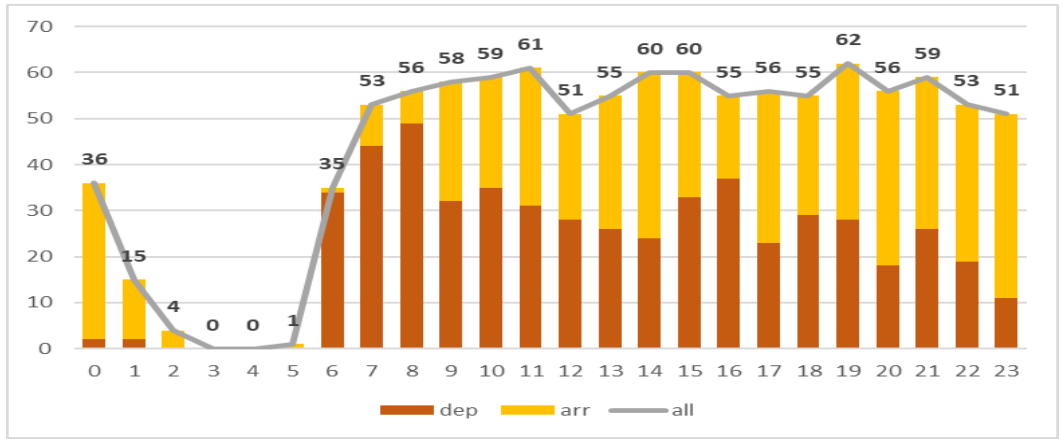
RunwayDependency(separation)

RunwayEntrySelectionRule,
RunwayArrivalSeparationRule，
ApproachLegLocalSeparationRule,
ParkingPositionSelectionRule，
StopAndWaitRule,StartUpClearance，
PushBackClearance, TurnAround…

2.What major matters should be forcus on



ZBAD



ZBAA

FlightPlan

Design Day:Peak Month, Peak day(Rank list 95% high in a year), On_time Performance 85%

Each Flight： AircraftType, Registration, Origin, Destinate, Dep time, Arr time, Routes, RFLs…

2.What major matters should be forcus on

Evaluation Result Report:

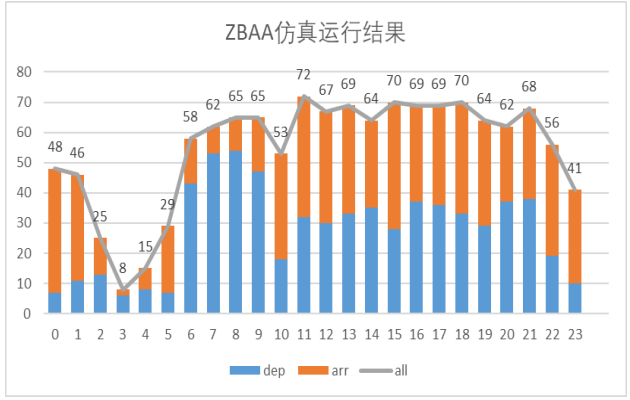
(1) A/C Movements in 5/15/60 Minutes

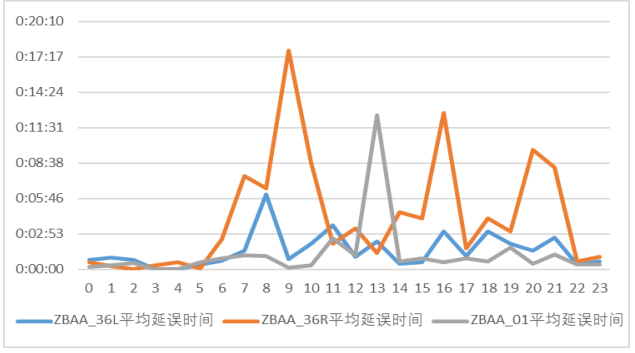
(2) Delay:Groud Delay,Arrival Delay

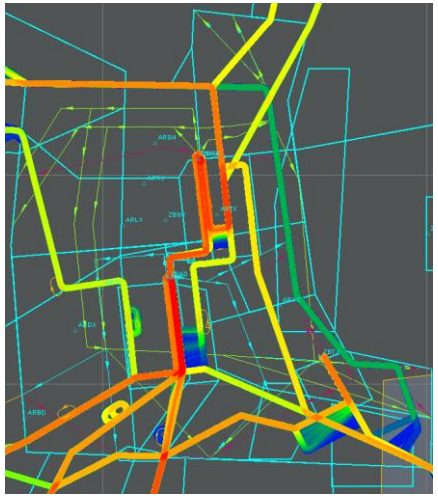
(3) Time: Taxi-in,Taxi-out,On_Time Performance

(4) ATC Workload

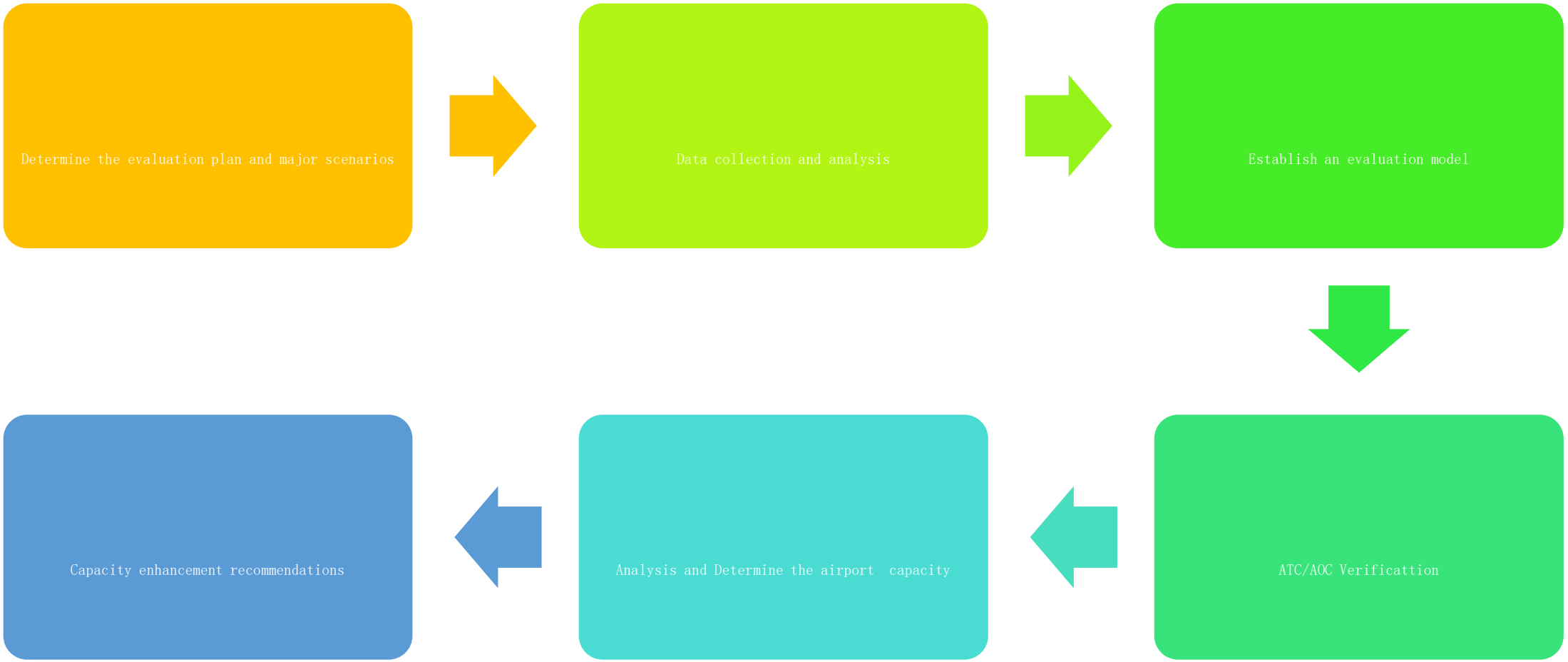
(5) Traffic Density:Trajectory





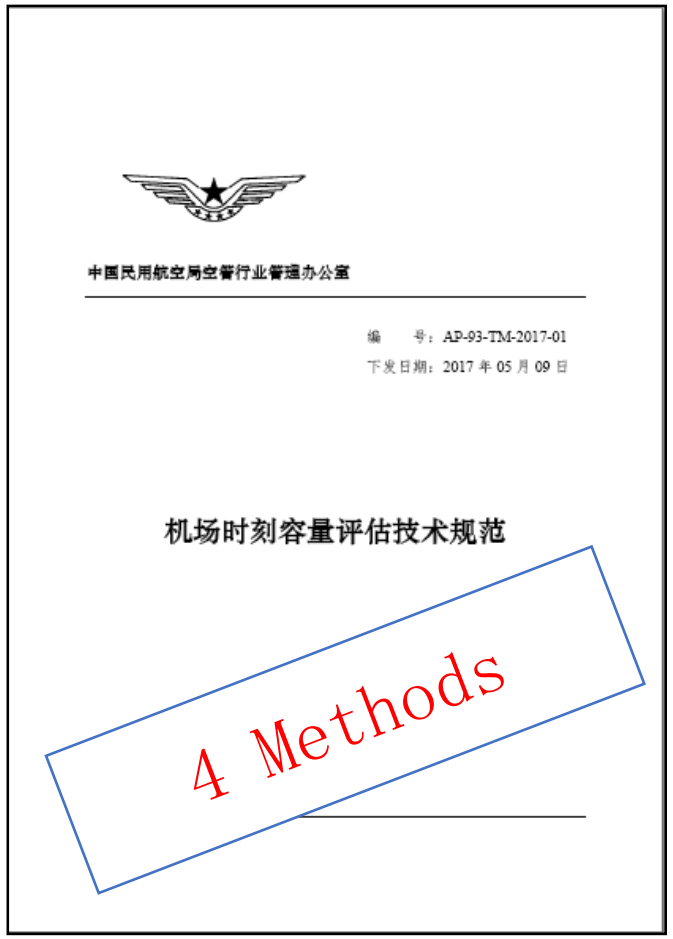


3.How to carry out Capacity Evaluation



Process of Airport Capacity Evaluation

3.How to carry out Capacity Evaluation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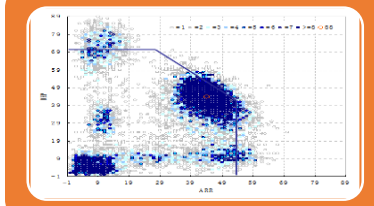
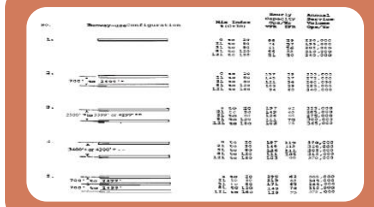
机场时刻容量评估技术规范

4 Methods

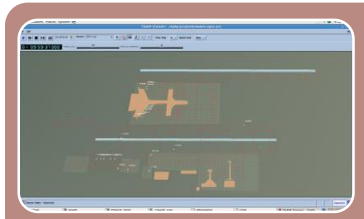
Technical Specifications of Airport Capacity Evaluation



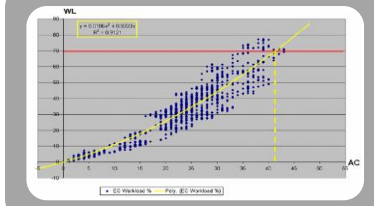
method based on historical statistics



method based on mathematical calculation model



method based on computer simulation model

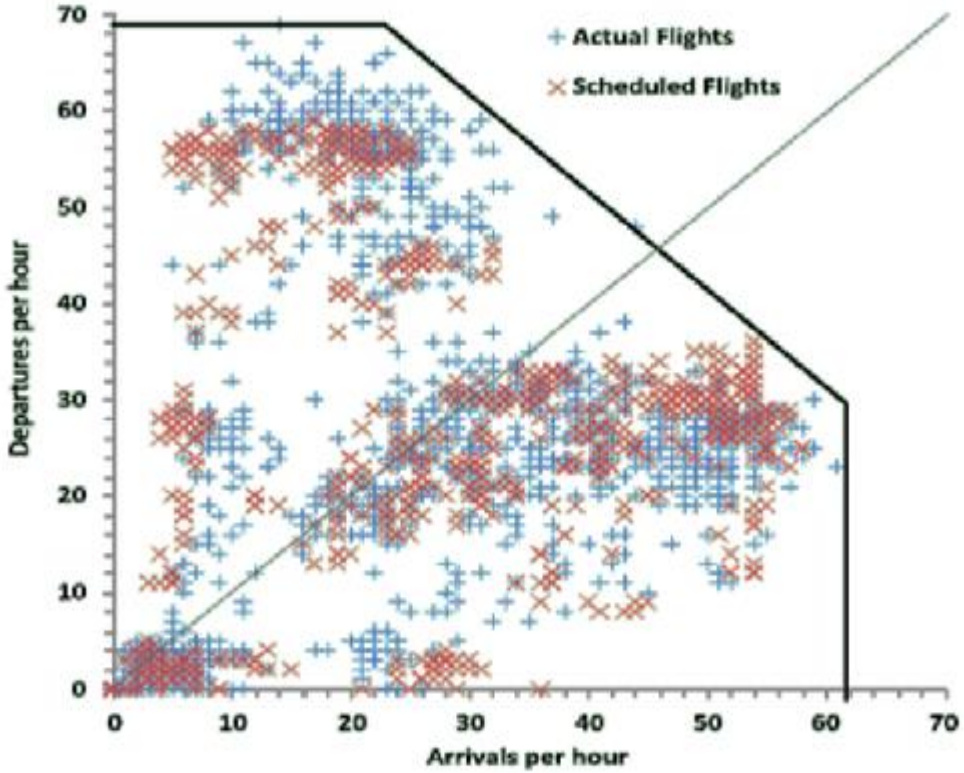


method based on controller workload

3.How to carry out Capacity Evaluation

Historical statistics

- Exploring the current airport operating characteristics and regularity by statistical analysis of a large number of historical running sample data of typical busy airports.

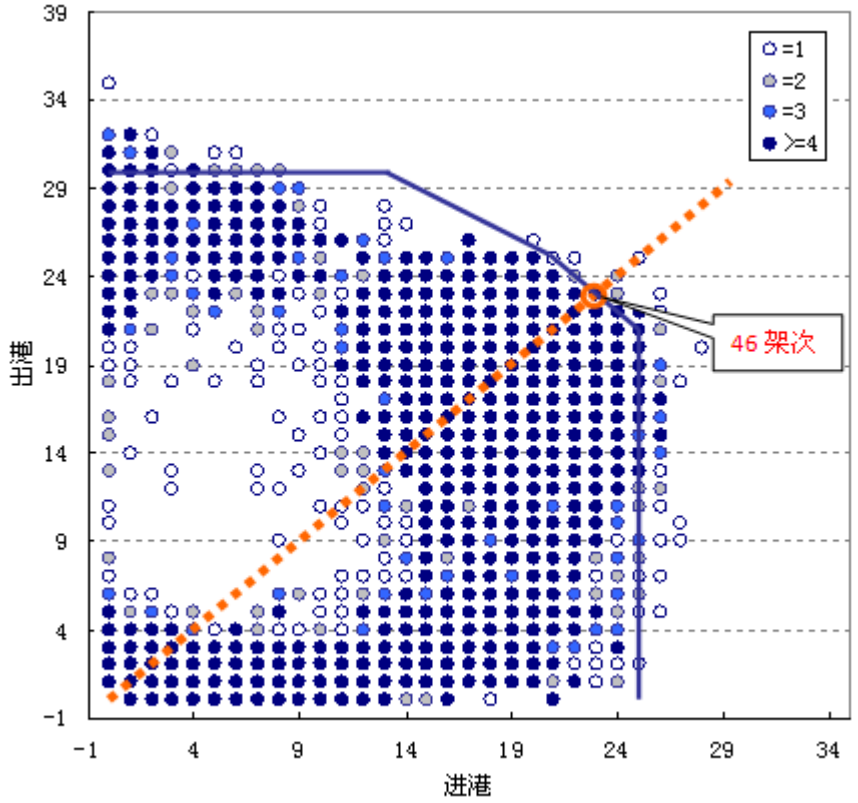


Capacity Curve

3.How to carry out Capacity Evaluation

Historical statistics

After a certain time period (e.g a month, a season), a **post-operations analysis** will reveal the highest sustainable throughput values that the airport has been able to accommodate. This can be determined by analysing **All actual traffic during the period**, and looking at the traffic levels during typical busy-hour periods (the approach excludes any exceptional performance achieved during the busiest hours of the period). This typical busy-hour indicator is called the **Peak service rate**.



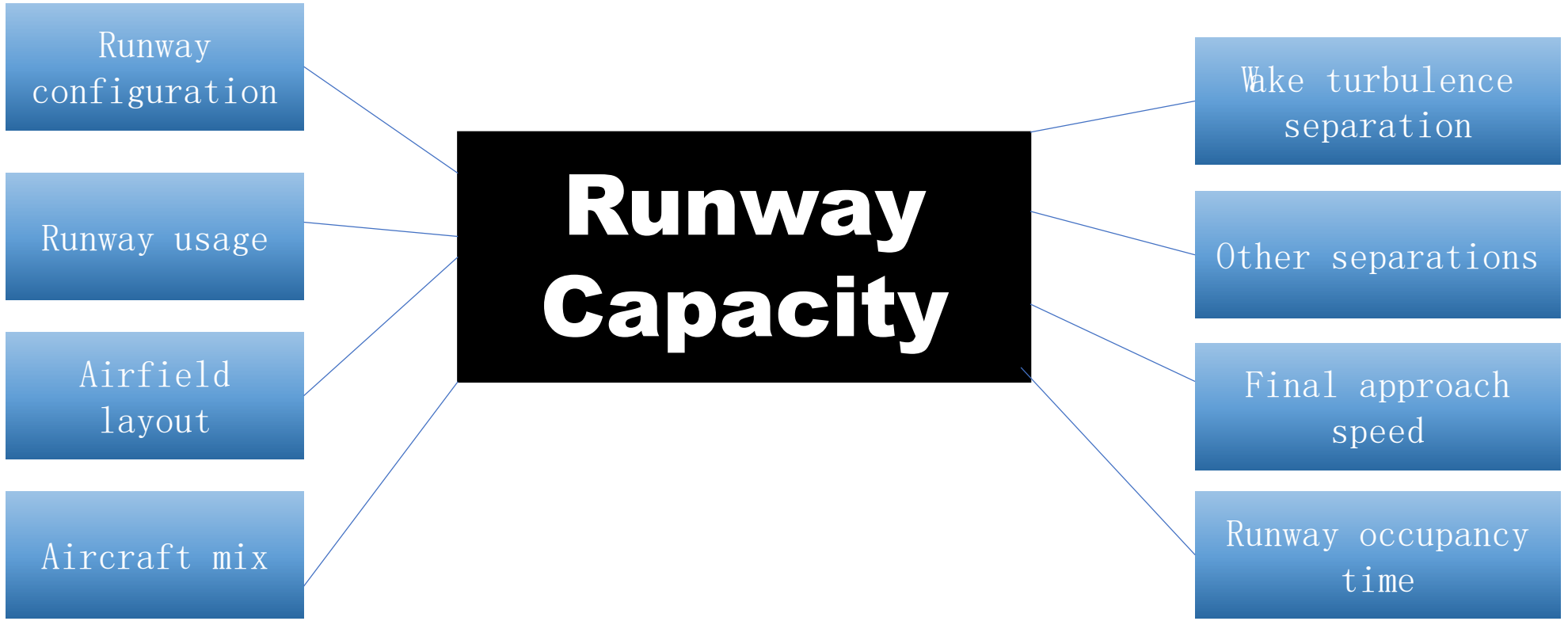
3.How to carry out Capacity Evaluation

Mathematical calculation model

- Based on factors such as **runway** operation or terminal operation.
- A mathematical model reflecting the operational characteristics of the runway or terminal building is established, and the runway capacity or the theoretical capacity of the terminal is calculated.
- The evaluation method is currently mainly applicable to the evaluation of **Runway capacity** and theoretical capacity of the terminal.

$$C_A(DA) = \frac{1}{E\left[T_{ij} + B_{ij}\right]} = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n} p_{ij}\left(T_{ij} + B_{ij}\right)}$$

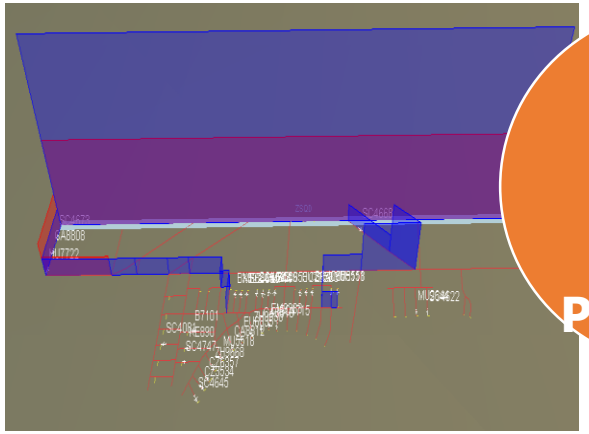
3.How to carry out Capacity Evaluation



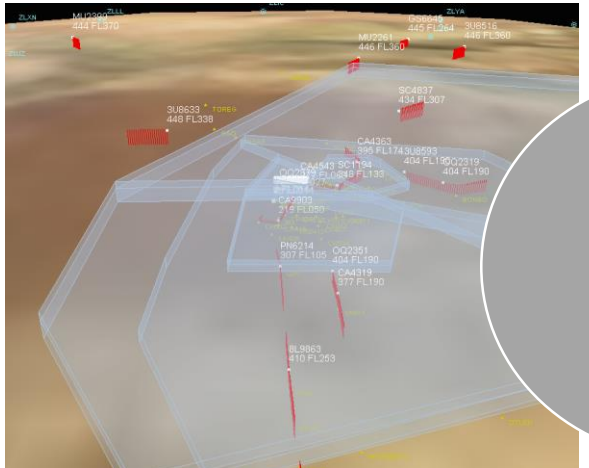
- **Runway Capacity：** The maximum number of aircraft operation that an airport runway can serve in a unit time without violating the air traffic control rules in case of continuous service requests.

3.How to carry out Capacity Evaluation

Computer Simulation Model



Parameter

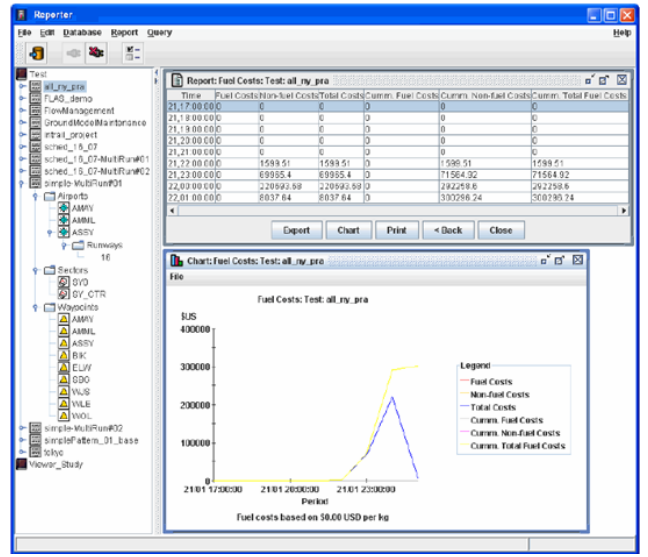


Rules

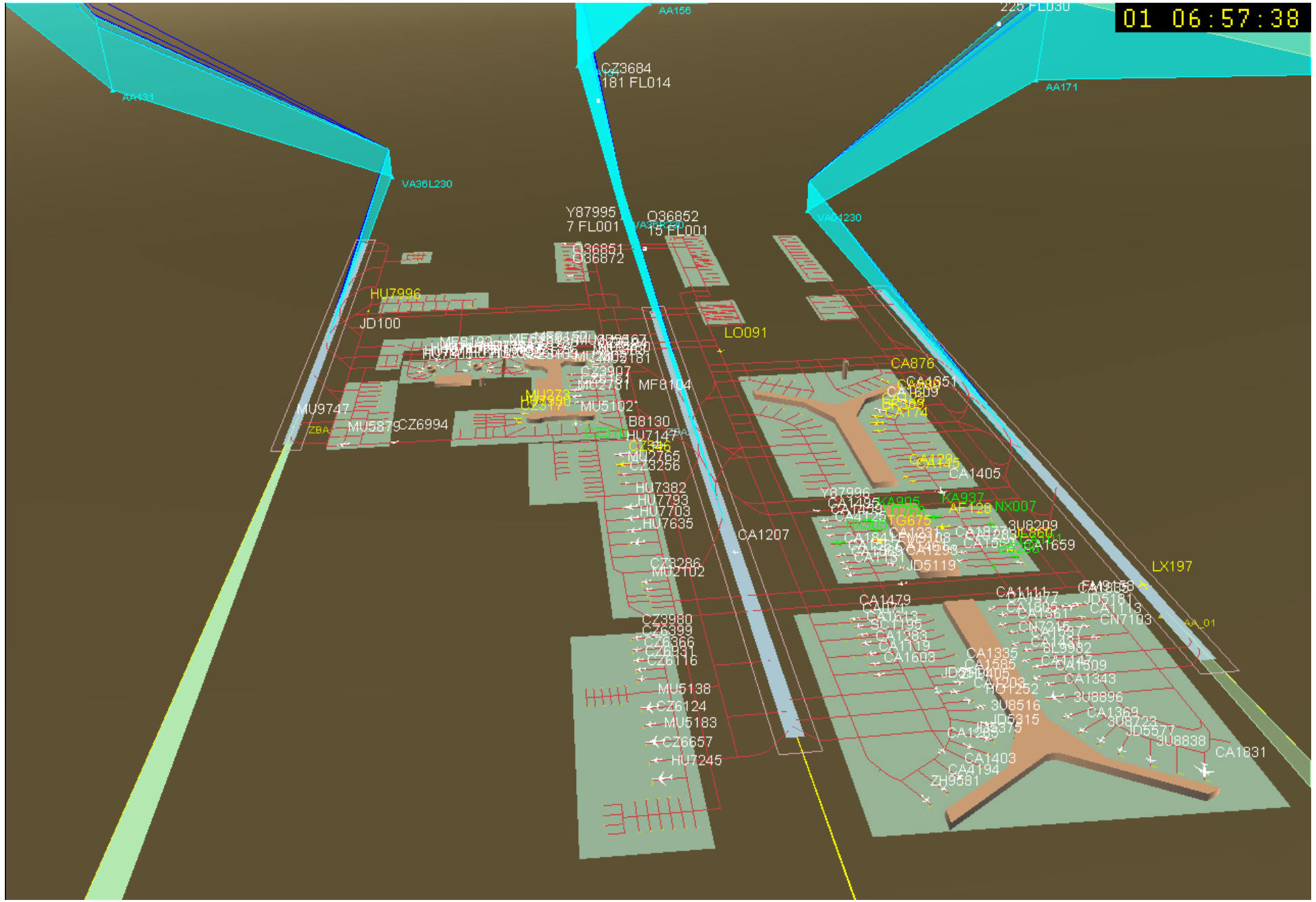
Total Airspace/Airport

Moduller SimulationAnalysis

TAAM, AirTop, SIMMOD



Result analysis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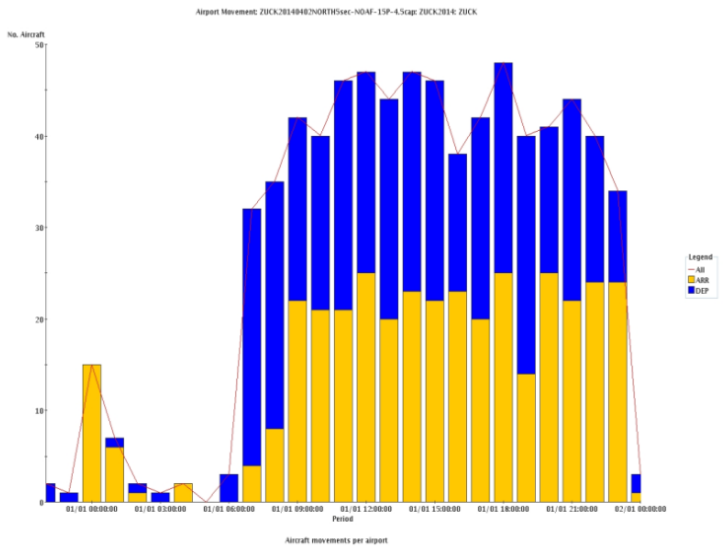
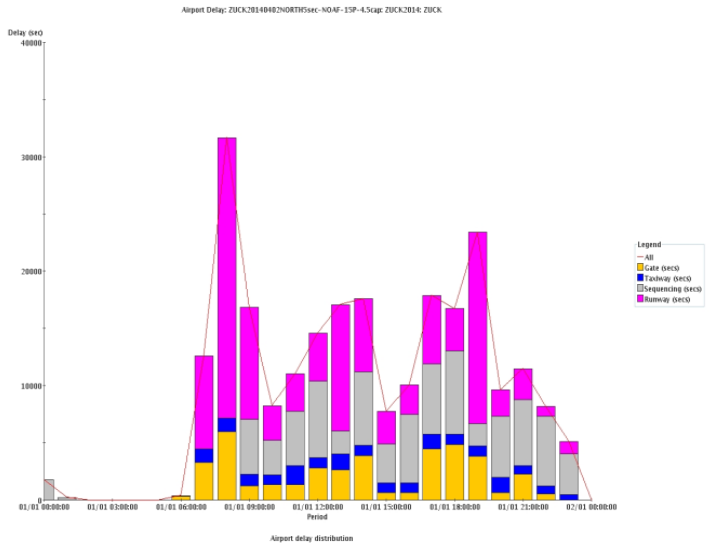
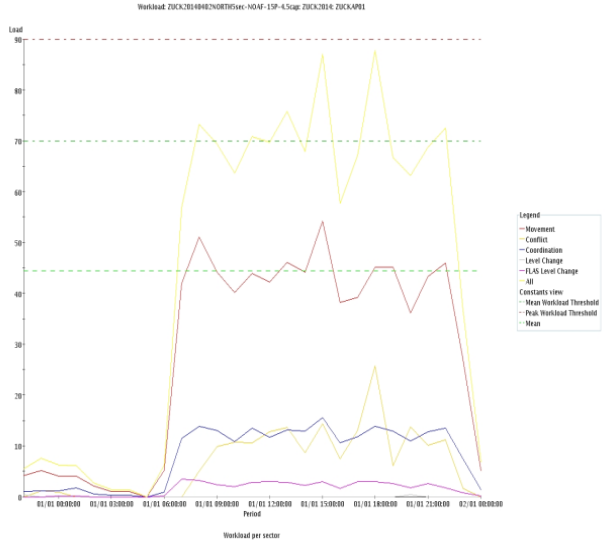
3.How to carry out Capacity Evaluation

Computer Simulation Model







Day Movements	Peak 3 Hour Movements	Peak 3 Hour Delay(s)	Peak Hour Average Movements	Peak Hour Average Delay(min)
649	121	25418	40.3	3.5
713	134	42565	44.7	5.3
745	138	49272	46	6.0

3.How to carry out Capacity Evaluation

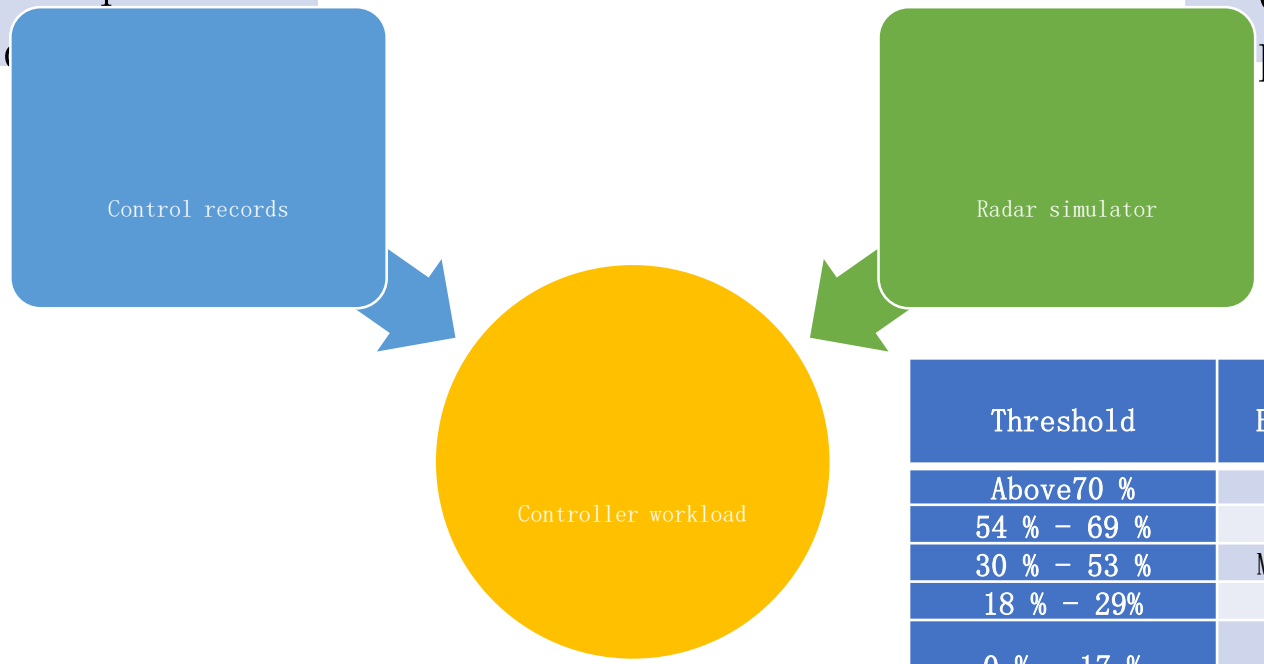
Controller workload

Events

- Aflight enters or exits an sector
- Conflict search and resolution
- New flight lever request
- Coordination, etc

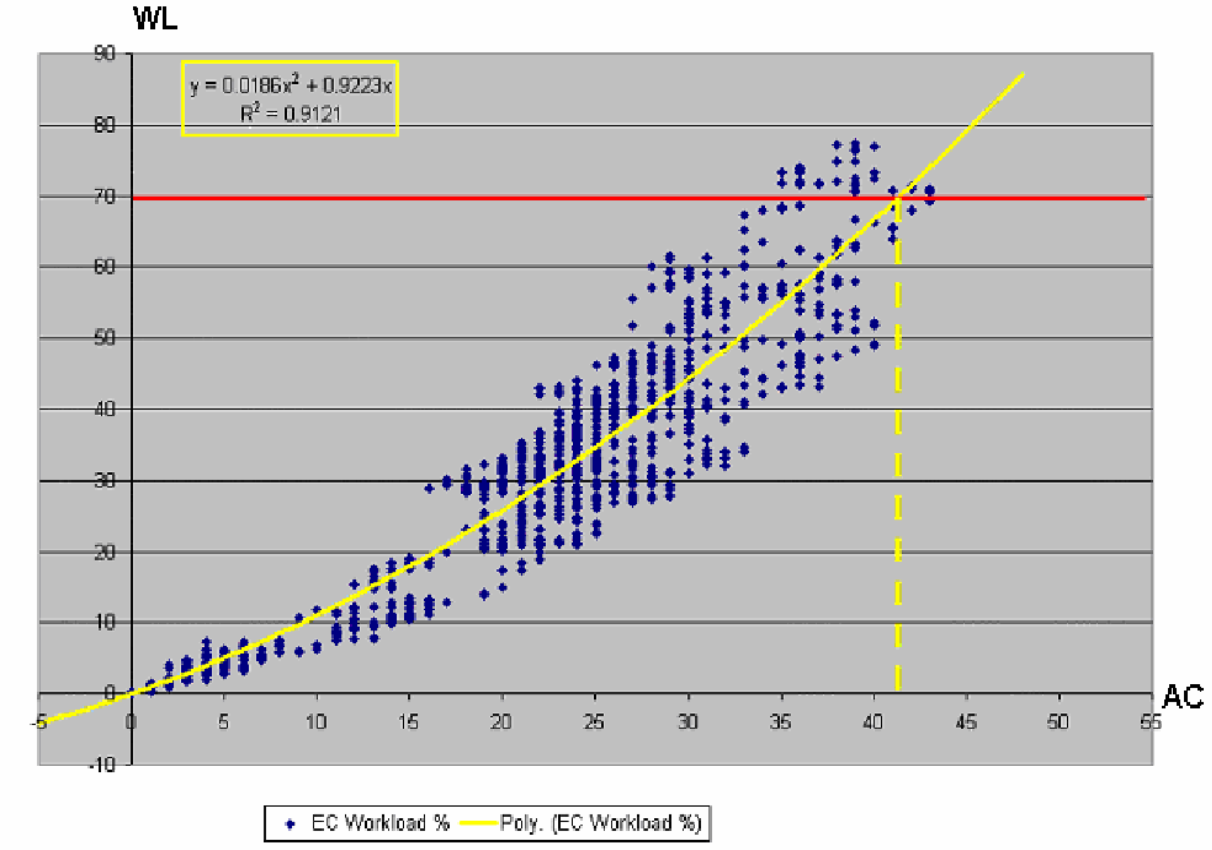
Data

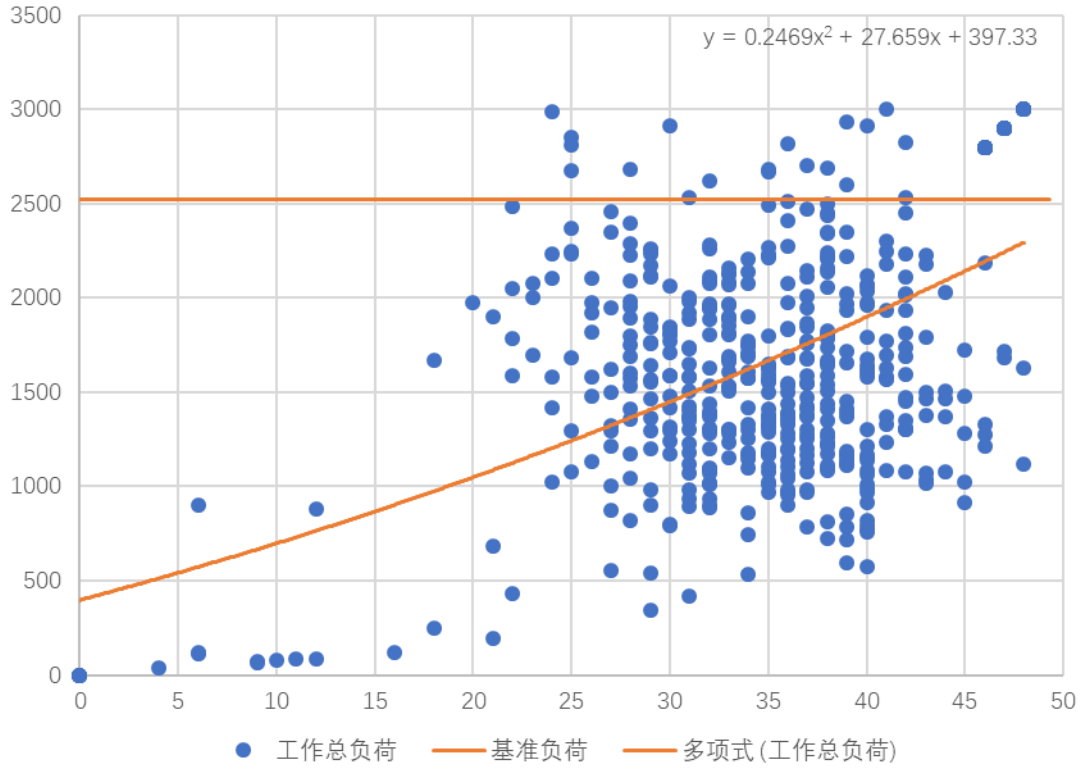
- Airspace environment description
- Flight plans or radar tracks
- Control parameters
- Duration of tasks



Threshold	Explanation	Recorded Working time(minutes)
Above70 %	Overload	42 +
54 % - 69 %	Heavy load	32 - 41
30 % - 53 %	Medium load	18 - 31
18 % - 29%	Light load	11 - 17
0 % - 17 %	Very light	00 - 10

3.How to carry out Capacity Evaluation

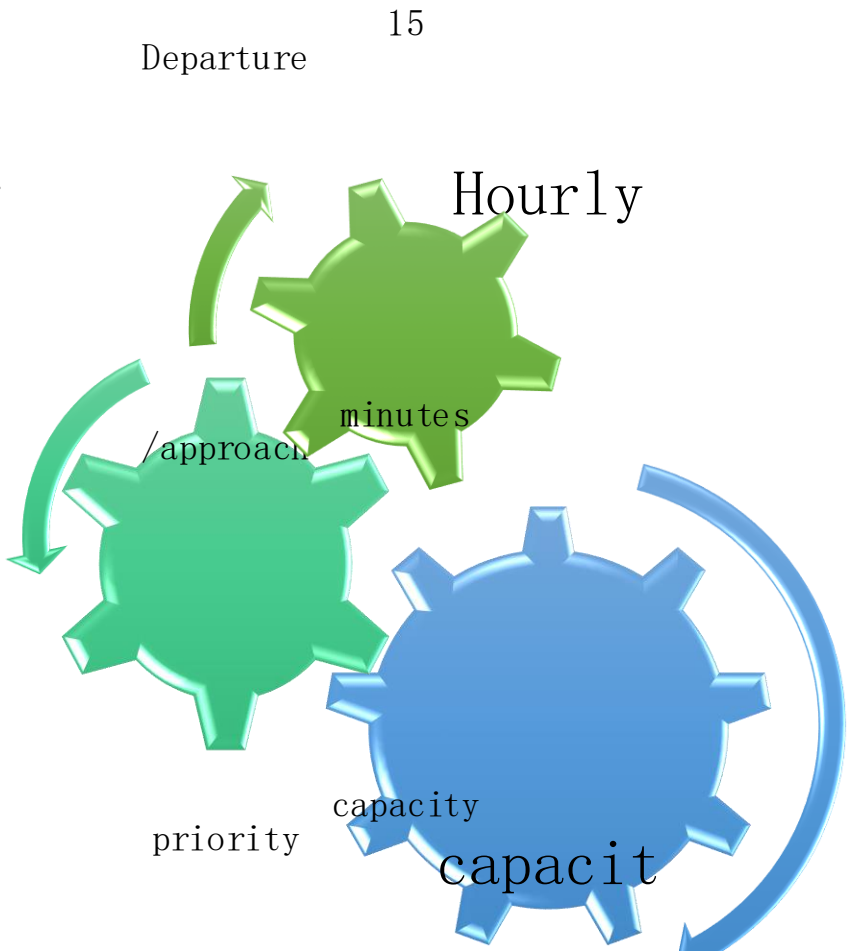




3.How to carry out Capacity Evaluation

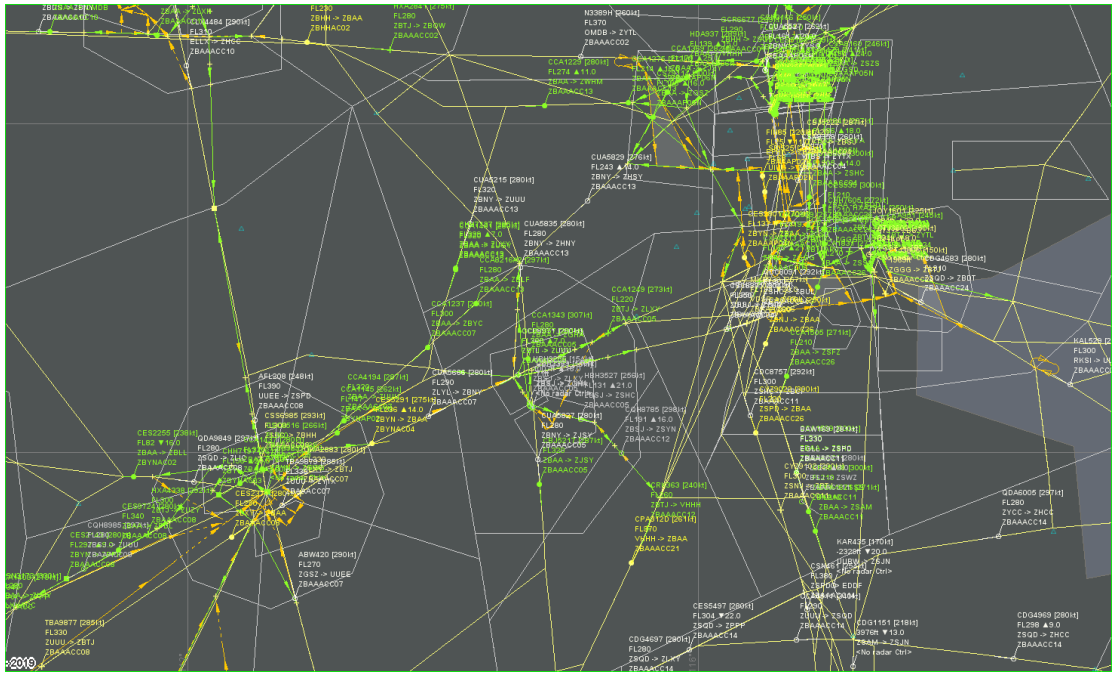
Capacity evaluation report

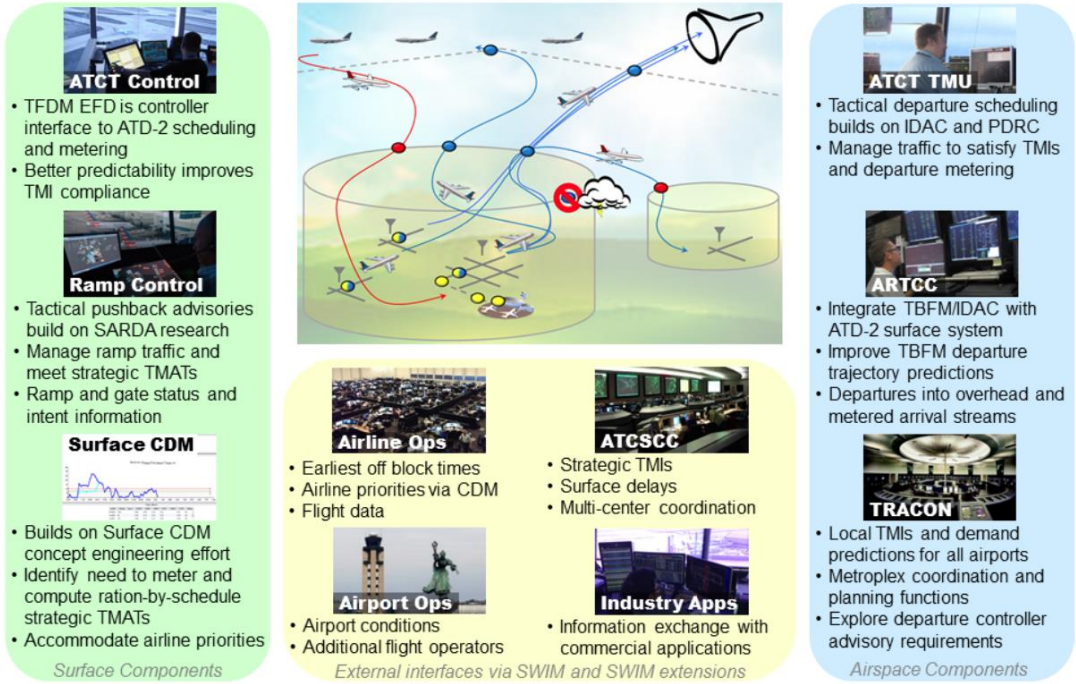
- Different scenarios capacity result;
- Operation bottlenecks;
- Suggestions about capacity improvements.



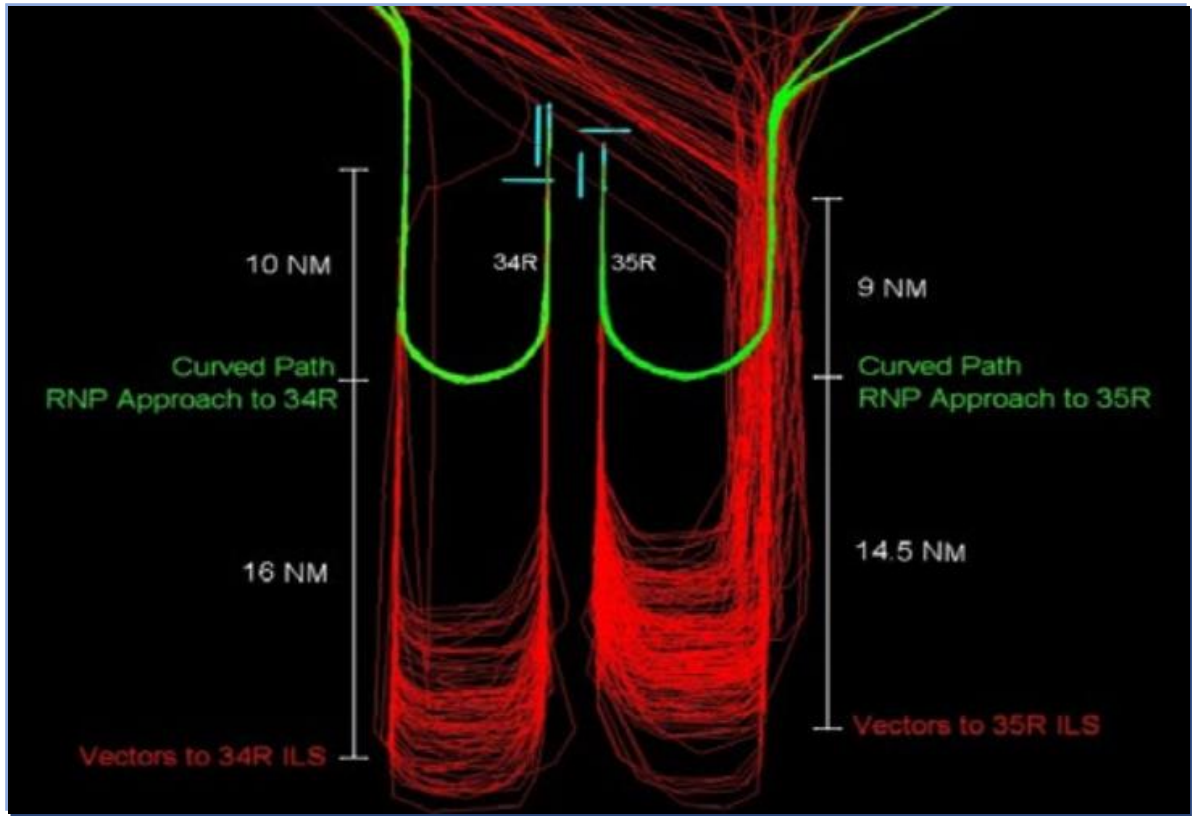
For Future ---Demand and Capacity Balance

- **Airspace ---DCB,Increase EnRoute/ATCSector Capacity and Efficence**
- **Airport ---DCB, Increase Throughput with High Performance**
- **SLOT---Flightplan Optimization and SLOT Utilization**





For Future ---Multiple Runway Airport Operation (EoR)



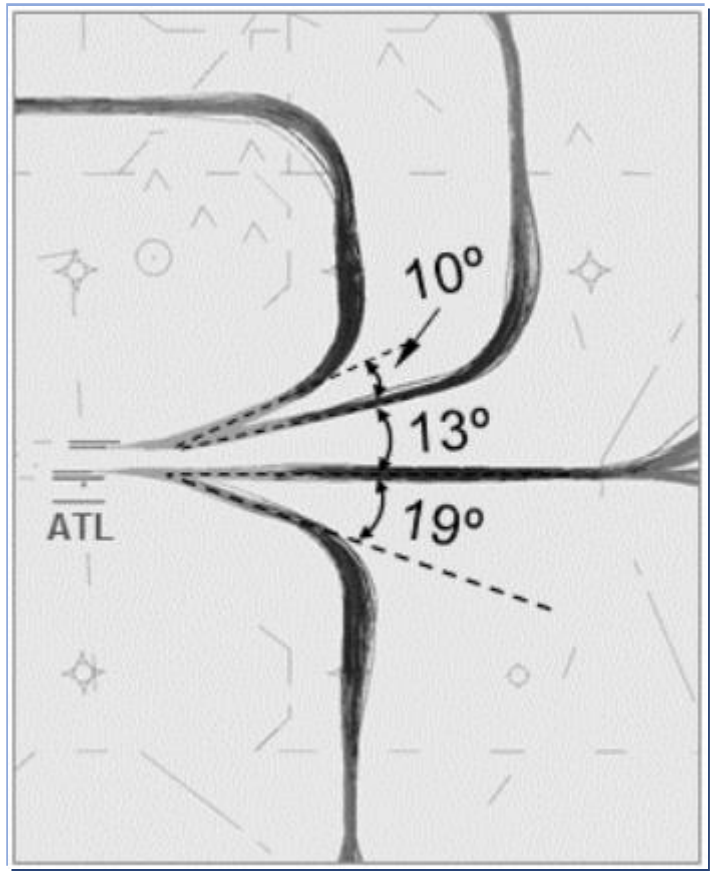
EoR enables controllers to clear aircraft on an RNP approach while on the downwind to the airport without the need to use the standard 1,000 feet of vertical or 3 nm lateral separation when the aircraft turns to align with the runway.

The new separation standards :

- **Enhanced TMA capacity**
- **Improved fuel efficiency**
- **Increased operational and cost efficiency**
- **Improved predictability**

Recently a study using EoR is carry out at KMG airport.

For Future ---Multiple Runway Airport Operation (ELSO)



Equivalent Lateral Spacing Operations (ELSO)

ELSO revises separation standard criteria by leveraging the predictability of PBN procedures to safely allow 10 degrees or more divergence after takeoff.

Compared with the non-ELSO standard requiring a minimum 15-degree divergence, this extra flexibility now allows for additional departures that increase throughput.


KLM896
060
OOACC
310
AUA373A
033
KLM35W
KLM11
013
DLH424
EZS91CF
013
ETI222T
122
EZY54AD
320
MGMKM
TRA2F
152
LOT279
360
TRA33E
NE6VD
TRA14E
VLG18TK
340
THY43D
240
AFR223M
380
RYR7DG
240
320
EZY47CN
380
340
RYR5FZ
380
OM8463
370
UAE9319
380
DCAPB
250
MLD834
370
BER42

Thanks

Hu Xiao Jiang, PhD, Professor-Level Senior Engineer , CAST

Work for CAST since 1998.

Participate in CAAC's *airport capacity evaluation temporary regulations 2010*, *airport capacity evaluation technical specifications 2017*, *research guide of airport master plan simulation analysis 2020*, etc.

Research areas include airspace and airport simulation, airport capacity evaluation, airport operation optimization, mid-air collision risk assessment, etc.

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